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Comparison of Single-Wall Versus Multi-Wall Immersive Environments to Support a Virtual Shopping Experience

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COMPARISON OF SINGLE-WALL VERSUS MULTI-WALL IMMERSIVE ENVIRONMENTS TO SUPPORT A VIRTUAL SHOPPING EXPERIENCE

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ABSTRACT

With the proliferation of large screen stereo display systems, major consumer product manufacturers are using this technology to test marketing ideas on consumers. One of the performance factors that is of interest to retailers or manufacturers of retail products is the ability of consumers to quickly and easily locate their products within a retail store. Virtual reality technology can be used to create a virtual store that is easily reconfigurable as a test environment for consumer feedback. The research presented in this paper involves a study that compares the use of a multi-wall immersive environment to a single-wall immersive environment. Users were given a list of products to find in the virtual store. A physical mockup of a shopping cart was created and instrumented in order to be used to navigate throughout the virtual store. The findings indicate that participants in the five-wall immersive environment were significantly faster in locating the objects than the participants using the one-wall immersive environment. In addition, participants in the five-wall condition reported that the shopping cart was easier to use than in the one-wall condition. This study indicates that the use of multiple walls to provide an increased sense of immersion improves the ability of consumers to locate items within a virtual shopping experience.

Keywords: Virtual reality, shopping, immersive environments, human-computer interaction.

INTRODUCTION

Virtual stores allow retail companies to test marketing strategies without spending the resources to physically implement new stores, displays, products etc. The participants will most likely be inexperienced users of virtual environments, thus the virtual environments have to be designed such that they are easy to use by an inexperienced user [1]. Within these virtual environments it is important to represent shopping experiences as realistically as possible which increases the user's sense of presence [2]. If the user has a high sense of presence in the virtual environment and the virtual experiences are an accurate representation of the real world shopping task, then companies can reliably use the virtual environments to survey participants about consumer preferences. The virtual environments currently used by major consumer products companies simulate a shopping experience by immersing the user in a three dimensional graphic and auditory environment.

Consumer products companies are concerned with how they can successfully survey consumers and reduce unnecessary expenditures at the same time. The research presented here examines whether multiple wall immersive environments enhance a consumer's ability to navigate in a virtual store. Navigation is, "the process of determining a path to be traveled by any object through an environment" [3]. In this experiment, navigation involved the users controlling their virtual movement in order to find products on a shopping list. The results are valuable to retail companies because if the five-wall environment creates a more realistic and natural shopping experience, companies would more likely rely on the results which may be worth the additional equipment expense.

The research question is: *Do multiple walls minimize the amount of time it takes a user to find products in a virtual store? Our hypothesis was that a five-wall immersive display would on average yield significantly shorter navigation times than a single-wall.*

BACKGROUND

Numerous studies have compared user performance in immersive displays. Pausch *et al.* [4] conducted one such study comparing user performance when searching for letters (i.e. 'A') in desktop and head-mounted virtual reality (VR) displays. They found that VR users were able to identify when there was no target letter present substantially faster than desktop users [4]. Kasik *et al.* [5] examined how the type of a display as well as the size of the display impacted search time when locating an item in a 3D desktop assembly of an airplane. They were unable to conclusively determine that the larger, more immersive display improved performance. Swindells *et al.* [6] followed up on Kasik's study and compared a CAVE (Cave Automatic Virtual Environment), single wall, and desktop displays on navigation time for finding airplane parts. Their results also suggested that display type does not significantly reduce the time it takes to find objects in a complex 3D model [6]. However, Tan *et al.* [7] found that a larger display increased user performance on path integration tasks.

In examining different interaction devices, Gabbard *et al.* [8] determined that past user input devices for virtual environments were not designed with the user in mind. Previous research has examined the benefits of hands-free navigation in a virtual environment [9], however, in designing this study we felt that the use of a physical shopping cart would significantly add to the user experience, especially for novice VR users.

There are other potential applications for virtual shopping environments. In the case of people with learning disabilities, a virtual environment can be used to help them learn how to find products in stores. Cromby *et al.* [10] looked at how students with severe learning disabilities shopped in a grocery store. The students were given a shopping list and told to find the specific items on the list. They found that the group who practiced shopping in the virtual environment was significantly faster the second time through the physical store than the control group. In addition, after the second time through the store, the experimental group had significantly more correct items in their cart than the control group.

METHODOLOGY

This user study compared the performance time of users in the virtual environment viewing only one front screen versus users in the virtual environment viewing four display walls and a display floor. This study was conducted using the C6 immersive reality room located in the Virtual Reality Applications Center at Iowa State University. The C6 is a 10 x 10 x 10 ft. room that has four walls, a ceiling, and a floor capable of displaying stereo images. Position tracking is also available in the C6.

During the task, all participants used the same shopping cart device (Figure 1) to control movement within the virtual store. The user was able to remain stationary in the C6 while simulating walking in the virtual environment by pushing forward and rotating the handlebar. The device resembled a modified shopping cart, with a physical stationary base and virtual basket displayed as part of the virtual store scene. The physical dimensions of the cart are 14" x 26" x 41". The virtual image of the basket was modeled to the same width and height of an average grocery store shopping cart, 24" and 40" respectively. To control forward and backward motion, a wooden handlebar was connected to a gamepad joystick. Participants could push or pull on the handlebar to simulate forward or backward motion in the virtual store. The handlebar system was mounted on a lazy Susan to permit rotation. An Intersense IS900 wand was secured beside the gamepad and used to get rotational data. To change direction or look around in the virtual store, users swiveled the handlebar left or right on the rotating base. The rotational data from the wand was used to rotate the viewpoint of the display while the translational data from the gamepad joystick was used to translate the viewpoint of the display. In this way, participants could steer the shopping cart to navigate through the store. In addition, the users were head tracked with the Intersense IS900 and wore CrystalEyes active stereo glasses.

For the one-wall display condition, handlebar rotation was restricted to turn at most, 45 degrees to the left and right of the starting position. To start turning in the virtual store, users rotated the handlebar to the left or right of the center and stopped the turning by bringing the handlebar back to center. In other

FIGURE 1. **SHOPPING CART DEVICE**

FIGURE 2. **VIRTUAL GROCERY STORE**

FIGURE 3. **A USER PARTICIPATING IN THE EXPERIMENT**

words, the virtual store revolved relative to the stationary viewer. In the five-wall display condition, users were free to rotate the handlebar 360 degrees. Contrary to the one-wall display, the virtual store remained stationary while the user physically turned the shopping cart device to the desired direction. Thus, the multiple-wall environment was more closely aligned with real world shopping environments.

At the start of the one-hour experiment, participants were asked to complete a brief survey about their background. The questionnaire asked participants about their education level, past experience with virtual reality, and familiarity with computer technology. Following the survey, they were introduced to the C6 and given a brief demo on how to use the mock shopping cart device to control motion in the virtual store (Figure 2).

Participants were randomly assigned to one of two groups. One group viewed the virtual store on one front wall of the C6 and the second group viewed the same virtual store on five-walls (sides and floor) in the C6. Participants in both groups were asked to complete the same task. They were given a paper shopping list of four products dispersed throughout the virtual store. The store layout as well as the product layout was the same for both groups. The participants' task was to locate the four products. When the participant was ready, he/she was asked to push a button on the shopping cart to identify that they were ready to start the experiment. When the participant found a product, he/she was instructed to push a button on the shopping cart to signify that they found an item. These button presses were saved to a file along with a time-stamp. The dependent variable was the time it took participants to find all four products in the store. In addition, the arc length or path that the user took was recorded. A participant going down one of the aisles can be seen in Figure 3.

Upon completion of the task, participants were asked to complete a short exit survey summarizing their experiences during the shopping task. The survey questioned participants about their level of stress, comfort, and how close their VR shopping experience was to a real one.

RESULTS

Eleven participants were chosen for a pilot study. The pilot study identified two deficiencies in the software and the methodology. First, the speed in the virtual world, both in terms of forward movement as well as rotational speed, was too slow. In addition, participants noted that they had problems finding one of the products due to their unfamiliarity with that specific product. In response to this, the software was revised to increase the navigation speed and the unfamiliar product was replaced with one more familiar to most people. Twenty-three participants were included in the final study.

Participants were mostly undergraduate students with ages ranging from 20 to 45 years old (M = 24.13, SD = 6.52). There were 14 male and 9 female participants. Self reported computer experience was on a Likert scale between 0 (no experience) and 10 (high computer experience) with a mean (M) of 6.13 and a standard deviation (SD) of 2.15. Most of the participants had little experience with virtual reality as was self reported on a Likert scale between 1 (none or little experience) and 10 (significant experience) (M = 3.04, SD = 2.68).

Six participants did not finish finding all the products due to feeling sick or dizzy. Of those 6 participants, 2 participated in the one-wall condition and 4 participated in the five-wall condition. The data from the remaining 17 participants who finished was analyzed using a one-way ANOVA (F-test). Ten participants experienced the one-wall condition and 7 experienced the five-wall condition. Participants in the five-wall condition were significantly faster (see Figure 4) than the one-wall condition, $F(1, 15) = 6.13$, $p = .02$. The five-wall condition (N = 7, M = 4.6, SD = 2.11) had a lower mean and standard deviation than the one-wall condition (N = 10, M = 7.52, SD = 2.56). Since the environment started rotating whenever the mock shopping cart rotated left or right of the starting forward position, we observed many individuals in the one-wall condition who had trouble navigating. This may be one explanation for the large variation in time. The blue circle in the five-wall condition in Figure 4 is an outlier and was the longest time in this condition.

In analyzing the questionnaire information using the same one-way ANOVA (F-test), all 23 participants were included. Only one difference resulted in statistical significance at the 95% confidence limit. Participants in the five-wall condition reported that the shopping cart was easier to use than the participants in the one-wall condition, $F(1, 21) = 6.17$, $p = .02$.

Overall, the participants in the five-wall condition had a better experience than their counterparts in the one-wall condition even if the remaining question items resulted in no significance difference. Participants in the five-wall condition felt the experience was more "natural" and representative of a real shopping experience than those who participated in the one-wall condition, $F(1, 21) = 2.35$, $p = .14$. Participants in the five-wall condition felt that the setup was more convincing in terms of reality than the one-wall condition, $F(1, 21) = 3.78$, $p = .06$. Participants in the five-wall condition reported feeling more comfortable in the store than those in the one-wall condition, $F(1, 21) = 2.91$, $p = 0.1$. Participants in the five-wall condition reported feeling less sick, $F(1, 21) = 1.64$, $p = .2$. In addition to the 6 participants who did not finish, there were 3 additional participants in the single-wall condition who finished but specifically mentioned afterward that they felt ill or dizzy. This may partially explain why there were more participants who did not finish and felt ill in the five-wall condition than in the one-wall condition, yet the five-wall condition reported feeling less sick. Participants in the five-wall experienced less stress, $F(1, 21) = 2.79$, $p = .11$. In addition, participants in the five-wall condition reported having a higher level of control moving around in the virtual environment than in the one-wall condition, $F(1, 21) = 3.07$, $p = .09$.

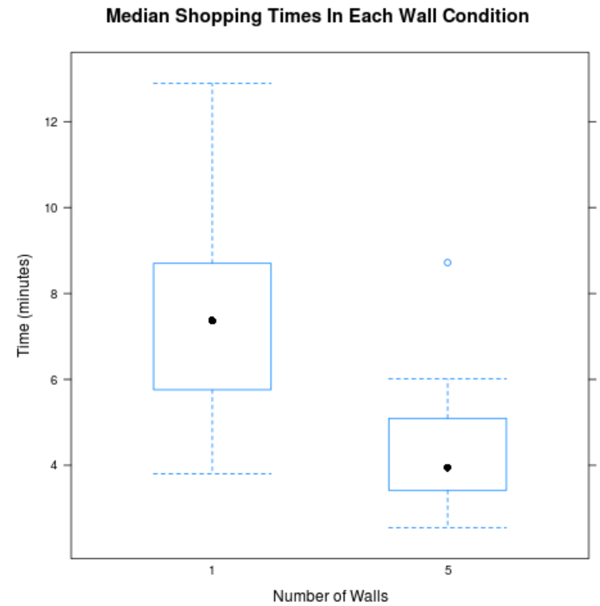

FIGURE 4. SHOPPING TIMES COMPARISON

CONCLUSION

There are many opportunities for further research using virtual shopping environments. The results suggest that the combination of the physical shopping cart and the virtual environment was fairly convincing to users. Anecdotally, one user even continued moving around the environment after finding all four of the products and went to the front of the store to the cash register machines to "checkout."

Simulator sickness was of peripheral interest before running the study, however, based on the results more analysis is needed. Questionnaires that specifically address this topic such as the one by Kennedy *et al.* [11] may be helpful.

A potential influencing variable in these results is the fact that collision detection was not implemented in this software. Therefore, users could move through store fixtures at will and were not constrained to move within the store aisles. This was the main reason why the arc length or path length data was not analyzed. Adding collision detection and examining what types of paths participants take through the store would be interesting to examine in the future.

In addition, another potential influencing variable is the difference in movement between the one-wall and five-wall conditions. The five-wall condition method of being able to move the cart in a complete circle was more indicative of a natural shopping experience and thus the reason why it was picked as a navigation method. However, this may have had an impact on the results as a confounding variable.

Potential future work could investigate other user input devices for virtual shopping experiences. An extension of this study could examine how the ceiling and floor walls influence a user's ability to find products. Future experiments using VR to study marketing strategies could test if the layout of the store or different types of aisle signs would reduce navigation time. In addition, examining how familiar product shapes and colors influence the ability of the participant to pick out that specific product in the aisle would be interesting to examine.

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